of the compound sound are made to strike on the membrane at different periods of their swings.

For example, if the compound sound is formed of six harmonics, the removal of the source of the sonorous vibrations, from the membrane to a distance equal to $\frac{1}{4}$ of a wave-length of the first harmonic, will remove the second, third, fourth, fifth, and sixth harmonics to distances from the membrane equal respectively to $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, and $1\frac{1}{2}$ wave-lengths. The consequence evidently is, that the resultant wave-form is entirely changed by this motion of the source of the sound, though the sonorous sensation of the compound sound remains unchanged.

The above facts are readily proved experimentally by sending a constant compound sound into the cone of König's apparatus, while we gradually lengthen the tube between the cone and the membrane next to the flame. This is best done by the intervention of one tube sliding in another, like a trombone. These experiments I have recently made with entire success, and they explain the discussions which have arisen between different observers as to the composition of vocal and other composite sound, as analysed by means of König's vibrating flames.

These facts also show how futile it is for any one to hope to be able to *read* the impressions and traces of phonographs, for these traces will vary, not alone with the quality of the voices, but also with the differently-related times of starting of the harmonics of these voices, and with the different relative intensities of these harmonics.

It is necessary to give to the cylinder a very regular motion of rotation while it receives and reproduces the vibrations made in singing; for even slight irregularities in the velocity of the cylinder destroy the accuracy of the musical intervals, and cause the phonograph to sing falsetto. Even the reproducing of speech is greatly

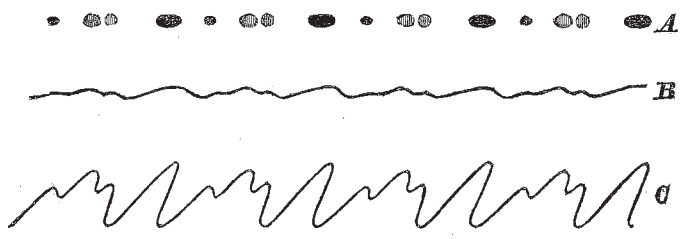

FIG. 3.

improved by rotating the cylinder by mechanism which gives it uniformity of motion. If you make the machine talk by giving it a more rapid rotation than it had when you spoke to it, the pitch of its voice is raised; and by varying the velocity of the cylinder the machine may be made to speak the same sentence in a very bass voice, or in a voice of a pitch so high that its sounds are really elfish and entirely unnatural.

Recent experiments seem to show that the nearer the diaphragm A approaches to the construction of the drum-skin of the human ear by "damping" it, as the hammer-bone does the latter, the better does it record and repeat the sonorous vibrations; for the motion of a membrane thus damped is ruled alone by the aërial vibrations falling on it.

Mr. Edison has just sent me the following notes of the results of recent experiments:—

"That the size of the hole through which you speak has a great deal to do with the articulation. When words are spoken against the whole diaphragm, the hissing sounds, as in *shall, fleece, last,* are lost; whereas, by the use of a small hole provided with sharp edges, these words are reinforced and recorded. Also, teeth around the edge of a slot, instead of a round hole, give the hissing consonants clearer.

"That the best reading is obtained when the mouth-piece, BFB (Fig. 2), is covered with several thicknesses of cloth, so that the snapping noise on the foil is rendered less audible.

"I send you a sheet of copper-foil upon which I made records in Ansonia, Connecticut, that could be read 275 feet in the open air, and perhaps farther, if it had been tried."

Mr. Edison also states that impressions of sonorous vibrations have been made on a cylinder of soft Norway iron, and from these impressions have been reproduced the sonorous vibrations which made them.

ALFRED M. MAYER

THE OLD RED SANDSTONE OF WESTERN EUROPE[1]

PART I.

IN a historical introduction the author gives an outline of the progress of research into the history of the Old Red Sandstone of the British Area. This system is at present regarded as composed of three sub-divisions, Lower, Middle, and Upper, each characterised by a distinct suite of organic remains. From the absence of unequivocally marine fossils and from lithological characters, it has been inferred by Mr. Godwin Austen, Prof. Ramsay, Prof. Rupert Jones, as well as other observers, and is now very generally admitted that the Old Red Sandstone, as distinguished from the "Devonian" rocks, probably originated in inland sheets of water. The object of the present memoir was to endeavour to trace out in that geological system of deposits the changes of physical geography which took place over Western Europe during the interval between the close of the Upper Silurian and the beginning of the Carboniferous period.

After a sketch of the probable conditions of the region previous to the commencement of the Old Red Sandstone, the author proceeds to show how the shallowing Silurian sea was converted here and there into *salinas* or inland seas, by a series of subterranean movements which have left their indelible traces upon the upturned Silurian rocks. He divides his memoir into two parts, the first dealing with the Lower and the second with the Upper Old Red Sandstone. The present paper deals only with a portion of the first of these sections. It traces out the limits of the different basins in which the Old Red Sandstone of the British Islands were deposited, and for the sake of convenience as well as briefness of reference, proposes short geographical names for these basins, which are arranged as follows:—

[1] Abstract of paper by Prof. Geikie, F.R.S., read before the Royal Society of Edinburgh on April 1, 1878.

Area of the Basins.	Short reference names proposed to be applied to them.
1. The Old Red Sandstone tracts of the north of Scotland, embracing the region of the Moray Firth, Caithness, the Orkney Islands, the mainland of Shetland, and perhaps part of the south-western coast of Norway.	Lake Orcadie.
2. The central valley of Scotland between the Highlands on the north and the Silurian uplands on the south, including the basin of the Firth of Clyde, and ranging across the north of Ireland to the high grounds of Donegal.	Lake Caledonia.
3. A portion of the south-east of Scotland and north of England extending from near St. Abb's Head to the head of Liddesdale, and including the area of the Cheviot Hills.	Lake Cheviot.
4. A district in the north of Argyllshire extending from the mouth of the Sound of Mull to Loch Awe, and perhaps up into the southern part of the Great Glen.	Lake Lorne.
5. The Old Red Sandstone region of Wales and the border counties of England, bounded on the north and west by the older palæozoic hills, the eastern and southern limits being unknown.	The Welsh Lake.

Lake Orcadie.—After describing the limits of this basin, and giving a sketch of the labours of previous observers in the Old Red Sandstone tracts of the north of Scotland, the author proceeds to examine the evidence for the threefold arrangement of the Old Red Sandstone proposed by Murchison. He shows that nowhere are the three groups, Lower, Middle, and Upper, found in consecutive order; that this so-called "Middle" division occurs only in the north of Scotland, where it lies unconformably upon the older palæozoic rocks, and is itself unconformably overlaid by the Upper Old Red Sandstone, thus occupying a position exactly similar to that of the Lower Old Red Sandstone on the southern side of the Highlands. He further points out that while some species of fishes are common to the Old Red Sandstone on the two sides of the Highland barrier, the lithological differences between the deposits of the two areas are so great as to make it evident that the rocks were laid down in distinct basins and consequently that the fauna of each basin might be expected to be more or less peculiar, as in many analogous cases at the present day. As evidence that adjacent areas in the time of the Lower Old Red Sandstone were strongly marked off from each other in their faunas, reference is made to the contrast between the fishes and crustaceans of the Welsh region and those of Lanarkshire and Forfarshire, not a single species being common to the two countries though some of the genera are. Reasons are then given why the argument used by Murchison from the occurrence of many of the Scottish ichthyolites in Russia could not be regarded as establishing the existence of a "Middle" division of the Old Red Sandstone.

The conclusion arrived at by the author is that the Caithness flags or "Middle Old Red Sandstone" are probably the general equivalents of the Lower Old Red Sandstone of other regions, and that this system consists in Britain of two well-marked divisions only—a Lower, which graduates in some places into the Upper Silurian rocks and is separated by an unconformability from an Upper which in many districts passes up into the base of the Carboniferous system.

The various districts into which the area embraced under the term Lake Orcadie may be divided are then described *seriatim*. The detailed structure of Caithness has been worked out by the author (partly with the co-operation of his colleagues in the Geological Survey, Mr. B. N. Peach and Mr. John Horne) as affording the most complete sections of the Old Red Sandstone in the North of Scotland. Arranged in descending order, the various stratigraphical zones stand as in the subjoined table:—

	Thickness in feet.
9. John O'Groats Red Sandstone, Flagstones, and impure Limestones and Shales	2000
8. Huna Flagstones, Shales, and Limestones ...	1000
7. Gill's Bay Red Sandstones	400
6. Thurso or northern group of Flagstones, Shales, and Limestones	5000
5. Wick or eastern group of Flagstones, Shales, and Limestones passing down into Red Shales and Sandstones	5000
4. Dull Red Sandstones, Red Shales, and fine Conglomerates...	2000
3. Brecciated Conglomerates	300
2. Badbea Red Sandstones and Shales or Clays..	450
1. Coarse basement Conglomerates	50
	16,200 ft.

From the four lowest sub-divisions no fossils have yet been obtained. The flagstones have yielded to Mr. C. W. Peach, and other observers many land plants (some of which resemble forms described by Dawson from the Gaspé sandstones) as well as *Estheria membranacea*, *Pterygotus*, sp., and many ichthyolites. Availing himself of the list of localities furnished to him by Mr. Peach (to whom he cordially acknowledges his obligations) with the species of fish found at each, the author has constructed a table of the vertical distribution of the fossil fishes in Caithness. Some of the species range through almost the entire succession of beds. Some, however, are either peculiar to or very characteristic of one sub-division. Thus *Osteolepis arenatus* and *Dipterus Valenciennesi*, are not noted except from the group No. 5. In the Thurso and the higher flagstones (Nos. 5, 8, and 9) *Acanthodes*, *Parexus*, *Cheiracanthus*, *Diplacanthus*, *Pterichthys*, *Tristichopterus*, and *Holoptychius*—genera absent from the Wick beds—are found in greater or less abundance. These strata are further marked by peculiar species of genera which likewise occur among the older flagstones, as *Coccosteus pusillus* and *Osteolepis microlepidotus*.

The Orkney Islands are assigned to the higher sub-divisions of the flagstone series, the protruding ridge of granite and gneiss which rises at Stromness and Gremsa being merely an indication of the irregular surface, on which the deposits of Lake Orcadie were accumulated, and of the slow progressive subsidence of the area. The fossils, for which these islands have long been famous, include most of those of the upper groups of Caithness, with the addition of others which have been regarded as distinct. In the determination of these fossils much skill is required to discriminate between the accidental differences of aspect resulting from the condition of fossilisation. The Orkney fishes, for instance, are preserved as black jet-like impressions which, often very perfect when first removed from the quarry, are apt to scale off, leaving in each case only an amorphous layer which, though it retains the contour of the fish, shows little or no trace of structure. On the shores of the Moray Firth, on the other hand, the organisms have been inclosed within calcareous nodules; their colours are sometimes brilliant, and their scales, plates, fins, and bones, are often admirably preserved and remain unchanged in the Museum. Want of experience in these different modes of preservation may have led to a reduplication of species, especially in the case of the Orkney and Moray Firth fishes. Among the most interesting Orkney fossils is a portion

of a *Pterygotus* (recognised by Dr. H. Woodward), now in the British Museum. The occurrence there of this characteristically Upper Silurian and Lower Old Red Sandstone genus supports the view contended for in this paper as to the true horizon of the Orkney and Caithness flagstones.

The Shetland Islands contain a portion of the shore-line of Lake Orcadie with its conglomerates and sandstones and the flagstones and shales of deeper water. Among these strata the Caithness *Estheria* occurs, with abundant stems and roots of large calamite-like plants with well-marked flutings but without observable joints. Some ichthyolites of the Caithness type are said to have been found in Bressay. The general lithological characters are quite those of the sandy parts of the Orkney and Caithness groups. On the west side of the mainland of Shetland interesting evidence occurs to show the existence of volcanic action contemporaneous with the accumulation of the Old Red Sandstone. Beds of amygdaloidal lavas and bands of tuff occur among the sandstones, the whole being pierced by masses of pink felsite.

The south-western and southern margin of this great northern basin of the Old Red Sandstone can still be traced nearly continuously from the confines of Caithness to the borders of Aberdeenshire, its position being marked by a zone of littoral conglomerates. Beyond the edge of that zone, however, there occur some interesting outliers which in some cases may represent long fjord-like indentations of the coast line; in others may mark what were really independent basins lying at the base of the Grampian Mountains. The author points out that probably most of the difficulty which has hitherto been experienced in understanding the sequence of beds along the southern shores of the Moray Firth and their parallelism with those of Caithness and Orkney is not to be attributed to the amount of detritus covering the country, but rather to the fact which has not heretofore been observed that the Upper Old Red Sandstone with *Holoptychius* and *Pterichthys major* really overlap unconformably upon the older nodular clays and conglomerates with *Coccosteus*, *Cheirolepis*, &c. This relation could be satisfactorily determined in Morayshire, and was now being worked out by Mr. John Horne in the course of the Geological Survey. The author traces in great detail from the Spey into Sutherlandshire, the development of the lower sandstone conglomerates and clays, which have been regarded as equivalents of the Caithness flagstones. He thinks that in no sense can this comparatively thin group of rocks (seldom 1,400 feet in depth) be regarded as a mere southward attenuation of the great Caithness series, as suggested by Murchison, for that neither lithologically nor palæontologically can that view be sustained. He has been led to the conclusion that the whole of these rocks from the borders of Sutherlandshire to those of Aberdeenshire represent only the higher portions of the great Caithness series, and that they were formed during a gradual depression of the ancient high grounds whereby the waters of Lake Orcadie were allowed to creep southward over the descending land. This movement is indicated by the character of the strata, and that it took place about the time of deposit of the later flagstones of Caithness is shown by the occurrence of the fossils of that division in the nodules, flags, and clays of the Moray Firth region, while those of the Lower division are absent.

Allusion is likewise made to the discovery of two localities where contemporaneous volcanic action has recently been observed in the Moray Firth area, the whole of the basin of Lake Orcadie being otherwise remarkably free from any trace of such action except on the northern margin in Shetland. The history of the area embraced by Lake Caledonia will form the subject of the next paper.

NOTES

We regret to have to announce the death of Dr. F. Brüggemann. Dr. Brüggeman was a native of Bremen and studied at Jena, where he was for several years assistant to Prof. Haeckel. His earliest publications were on entomological subjects, but later he published an account of the Amphibians and Reptiles of Bremen. He was especially interested in ornithology, and amongst other papers on this subject published two on the Birds of South-Eastern and Central Borneo (*Abhand. d. naturw. Vereins zu Bremen*, Bd. v. u. vi.). On the recommendation of Prof. Haeckel, Dr. Brüggemann was engaged last year by Dr. Günther to arrange and catalogue the collection of corals in the British Museum. Whilst in the midst of this undertaking he died suddenly at his lodgings on the night of Saturday last of hæmorrhage from the lungs. He had already named 1,500 species of corals in the collection, and had published two papers on undescribed forms in the *Annals and Magazine of Natural History*. He had in hand a revised list of all species of recent corals hitherto described, which was in an advanced state and which he had intended to have published. He was of an extremely amiable disposition and his loss is deeply regretted in London by the staff of the British Museum and other naturalists with whom he was acquainted. He was under thirty years of age at the time of his death.

On Thursday last the members of the General Council summoned to deliberate upon the improvements required in the organisation of the Paris Observatory waited upon M. Bardoux, the Minister of Public Instruction. They insisted upon the necessity of continuing the existing connection between astronomy and meteorology in accordance with the principles established by M. Leverrier himself, and developed the reasons which had led the majority to pass a resolution in favour of that system. A number of eminent scientific men had interviews with M. Bardoux, and have made a strong impression upon his mind. M. Bardoux has ordered all the letters from a number of departmental meteorological commissions to be summarised, and it has been found that not a single one has urged the disconnection of the two departments. We are in a position to state that according to every probability, during the present month, the Academy of Sciences and the new Council of the Observatory will be summoned to present each two candidates, between whom the Minister will exert his right of selection according to the provisions of the newly-published decree.

Captain Feilden, R.A., naturalist to the late British Expedition to the Arctic Regions, and Mr. De Rance, of H.M. Geological Survey, are announced to read a paper on the Geology of the Northern Lands visited, at the next meeting of the Geological Society of London, at which Mr. Etheridge will present a detailed report of the palæontology of the same area. We understand that the British Museum will probably be the destination of the very numerous collection of geological specimens made by Capt. Feilden, Dr. Coppinger, and other officers of the expedition.

M. Belgrand, Director of the Paris Sewers and Waterworks, died suddenly on the 8th inst. in his sixty-eighth year. To him Paris owes its network of sewers and its supply of water from the Dhuys, the Vanne, and the Somme Soude. He also devised the system of hydrological observations, by which floods are foreseen. As a connoisseur of water he is said to have had no rival.

It is stated that Prof. H. J. S. Smith, F.R.S., is to be a candidate for the representation of Oxford University in Parliament.

The coloured spherules discovered by M. Hannover in the cones of the retina of many birds are known to have three colours: a yellowish green, an orange yellow, and an intense